The High Cost of Low-Value Wind Power

Subsidized wind generates the least amount of power when it is most needed.

BY Jonathan a. lesseR

Many arguments have been made against subsidies for energy production, and against subsidies in general. By their very nature, subsidies distort markets and are economically inefficient, driving out legitimate competitors and leading to higher prices in the long run. They reduce incentives to innovate and improve operating efficiency. Subsidies are also inequitable because their costs are borne by the many while their benefits accrue to the—often politically connected—few.

Poor Justifications

Despite their obvious failings, energy subsidies—most notably for renewable sources like wind-propelled generation—continue to be justified in a number of ways. The most commonly heard arguments from renewable energy proponents have been, "We just need a little more time to become fully competitive," and, "Two wrongs do, in fact, make a right." More recently, proponents have added "green jobs" and economic development arguments, as if subsidized renewable energy could provide economic salvation. None of those arguments are valid.

The first justification is just the latest incarnation of the "infant industry" argument first made by Alexander Hamilton over two centuries ago. This argument asserts that renewable generation simply needs more time to innovate and reduce its costs to be fully competitive with fossil generation, at which point

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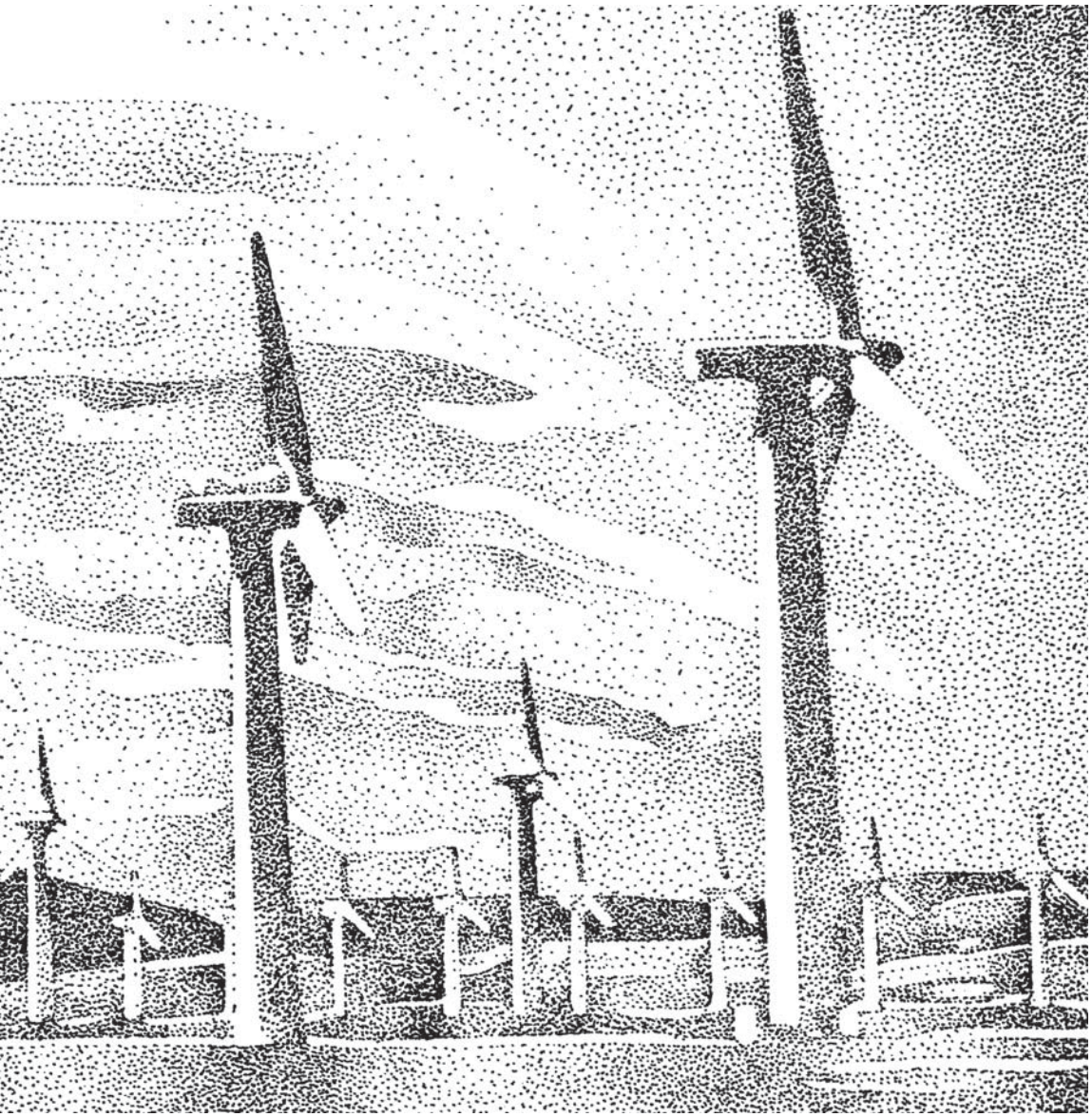
it will become a viable, welfare-enhancing industry. But renewable generation has been subsidized heavily for 35 years, ever since President Carter signed the Public Utilities Regulatory Policy Act and the Energy Tax Act in 1978. With passage of the Energy Policy Act of 1992 and creation of both the investment tax credit (ITC) and the production tax credit (PTC), these subsidies increased. The PTC currently stands at 2.2 cents per kilowatt-hour (kWh) on an after-tax basis. Based on the current 35 percent corporate tax rate, that translates into a before-tax credit of 3.4 cents per kWh, often larger than the wholesale price of electricity.

The second justification is simply a version of the "It's not fair!" argument, which parents know well. Renewable generation advocates argue that conventional generation has been subsidized for over a century; therefore, renewable generation deserves its subsidies, too, because that's only fair. While some forms of generation are subsidized indirectly, such as the Price-Anderson Act's limitation of nuclear plant owners' liability for accidents, other subsidies are often associated with general provisions of the tax code, such as accelerated depreciation schedules and tax-exempt bond financing by municipalities. Whether such accounting treatments are "subsidies" can be debated, but they are given to all generating resources. Renewable generation is the only type of generation that benefits from guaranteed revenues, such as the PTC and state "renewable portfolio standard" (RPS) mandates to purchase such generation at above-market prices.

The third and most recent justification, that economic salvation lies along a subsidized "green-energy" path, is not only a last refuge of the market-interventionist scoundrel, it has been discredited by experience. Not for nothing have countries such as Spain and Germany learned that green energy extracts a heavy economic price in the form of skyrocketing electric rates that damage other industries. Here in the United States, the promise of a new green energy economy is littered with the bankrupt remains of many companies that had received large checks from the U.S. Department of Energy, thanks to political connections and not technological and economic advantage.

Illustration by Morgan Ballard



Low-Value Electricity

Unlike other commodities, the value of electricity varies constantly in response to continuous changes in supply and demand. Consequently, the market value of electricity is always changing, from thousands of dollars per megawatt-hour in times of extreme electric demand, to below zero when markets are flooded with electricity supplies from generating resources, like nuclear plants, that cannot be turned on and off quickly or costlessly.

The constant change in market values, and the influence of subsidized wind generation on those values, reveals one of the greatest deficiencies of wind generation, and one of the reasons why subsidizing wind generation is grossly inefficient: wind produces low-value electricity. To understand why this is so, it helps to understand how the demand for electricity is met using a combination of baseload, intermediate, and peaking generating resources. Baseload generators, such as nuclear plants, have high capi-

tal costs but low variable operating costs. Accordingly, they are designed to run continuously, every hour of every day. Peaking generators, often oil- or natural gas–fired simple-cycle generators, operate when electricity demand is greatest, such as during hot and humid weather. Peaking units have relatively low capital costs, but high variable costs. For example, in New York City there are several very old and inefficient oil-fired generating plants. Because they are so expensive to operate, it is only when electricity demand is at its highest that they run.

Figure 1 provides an example. The heavy black line is called a "load duration curve" and represents electricity demand (load) at every hour, ordered from the highest demand hour to the lowest demand hour. Baseload generators, *B*, operate in all 8,760 hours of the year. There are two types of intermediate generators, I_1, which operate a total of H_{I-1} hours during the year, and I_2, which is assumed to have a higher variable cost and thus operates H_{I-2} hours during the year. Finally, there are peaking resources *P*, which operate the least amount, H_P hours, during the year. The number of hours during the year when each type of unit operates will be chosen to meet demand in every hour at the lowest possible cost.

FigurE 1

example load Duration Curve and generation types

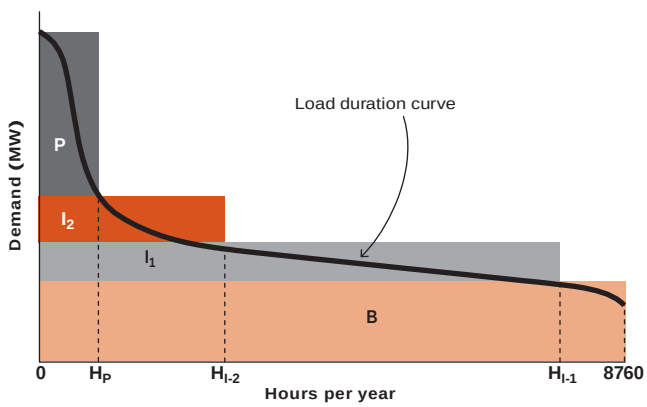
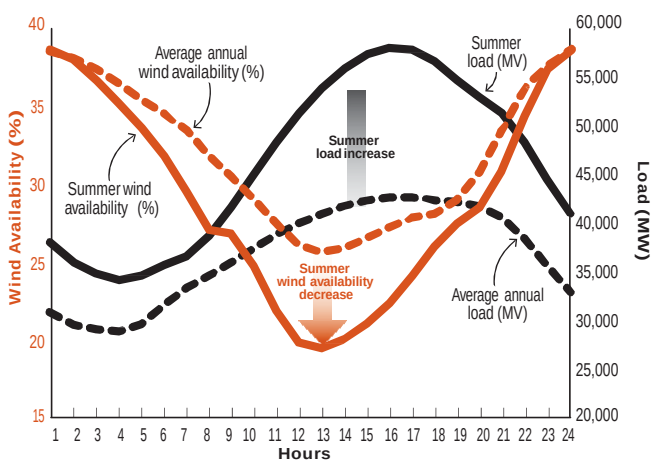


FigurE 2

Summer and annual load vs. Wind availability 2009–2012



The value of electricity in each hour represents the interaction of supply and demand. When electricity demand is greatest, consumers are willing to pay a high price for power, such as to remain cool on the hottest days. That is why peaking units with high variable operating costs are run at such times. Thus, the value of a particular type of generation depends on its ability to supply power when needed. In formal electricity capacity markets, total payments made to generators depend on their overall availability when needed. A generator with a history of frequent breakdowns and forced outages will be less valuable. Accordingly, it will be paid less than a similar unit that operates almost flawlessly because there is less certainty that the unreliable unit will be available when most needed. Similarly, a peaking unit that was not available to meet peak demand would have little or no economic value.

Wind generation is unreliable and thus suffers this fate. Wind generation is inherently variable and intermittent; it produces electricity only when the wind blows. Thus, wind generation can never be "counted on" to be available if needed. Worse, however, is the economically topsy-turvy pattern of wind generation in much of the United States: the least amount of wind-generated electricity is available when the economic value of electricity is greatest.

Empirical Analysis

The basis for this analysis is a review that my firm conducted of almost four years' of hourly production data (January 2009–August 2012) in three of the regional transmission organizations (RTOs) with the largest amounts of installed wind: the Pennsylvania-New Jersey-Maryland (PJM) Interconnection, which covers the mid-Atlantic states; the Midwest Independent System Operator (MISO), which covers the upper Midwest; and the Electric Reliability Council of Texas grid (ERCOT), which covers Texas. Together, these three regions account for about 27,000 MW of wind-generating capacity, over half of the approximately 50,000 MW of installed wind-generating capacity in the United States. With over 10,000 MW of wind-generating capacity, Texas contains the most wind generation of any state.

Our analysis shows that, whether examining the days with the highest electricity demand each year, on a seasonal basis, or based on hourly averages over the entire period, wind-generated electricity was least available when demand was greatest. Moreover, this inverse correlation was strong.

Consider first the average behavior of wind generation on an hourly basis throughout each day in ERCOT (Figure 2). Annual wind generation in ERCOT peaked between midnight and 1 AM (dashed red line), when electricity demand was near its lowest level (dashed black line). Worse, in summer, when electricity demand peaks at far higher levels in the late afternoon than during the year overall (solid black line), wind generation is far less than during the year overall (solid red line). This is precisely opposite of the value of electricity in these same hours. The relative lack of wind power is not surprising: the most miserable summer days

are hot, humid, and still. This is an aspect of wind power that its advocates avoid discussing.

We also examined the seasonality of wind-generated electricity in each year. For each season, we calculated the load–wind "gap," defined as the difference between the median seasonal wind availability ratio (i.e., average seasonal production relative to average annual production) and the seasonal load ratio (i.e., the average load during the season relative to average annual load). For example, suppose the average load in spring is 90 percent of annual average load, whereas average wind generation in spring is 120 percent of average annual wind generation. The load–wind "gap" would thus equal 120 – 90 = 30 percent. A *positive* load–wind gap value means there is relatively *more* wind generation available to serve load; a *negative* load–wind gap value means there is relatively *less* wind generation available to serve load. Ideally, the economic value of wind power is maximized if the most wind-generated electricity occurs when loads are highest. Just the opposite pattern is observed seasonally in each region. In summer, the load–wind "gap" is strongly negative, meaning that the least amount of wind power is generated during summer, when loads are at their highest on average. In PJM, for example, this gap was almost -70 percent in the summers of 2010 and 2011, and -60 percent in the summer of 2012 (Figure 3). Similar patterns are observed in ERCOT and MISO.

Finally, we evaluated wind generation on the summer days when electricity demand was greatest. It is those days when the economic value of electricity is greatest and, thus, when suppliers will most want to be available and providing power. Specifically, for each of the four summer seasons, we determined the median wind generation relative to total potential wind generation on the 10 highest-demand days. Yet again, the results are similar: there is little actual wind generation on the days when electricity is most valuable (Table 1), and far less than the median level of wind generation relative to its total potential during the entire year.

As Table 1 shows, median availability of wind generation on the days with the highest demand was much lower than during the entire year. In MISO, for example, median availability ranged from 1.8 to 7.6 percent over the four summer seasons, whereas overall median wind availability was 27 percent. Thus, if 1,000 MW of wind generation produced an average of 270 MW of power over the entire year, on the hottest summer days production would average as little as 18 to 76 MW.

Table 1

median Wind availability, Peak hour

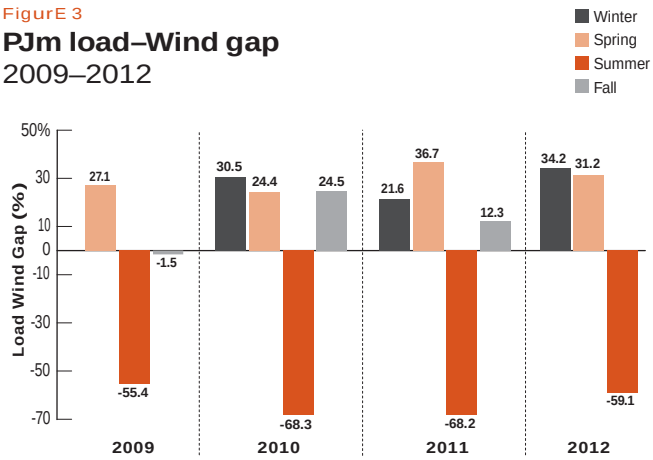
Top 10 days, 2009–2012

Region	Median availability peak hour, highest 10 demand days	Median availability all days, all hours
ErCOT	6.0% - 15.9%	30.9%
MiSO	1.8% – 7.6%	27.0%
PJM	8.2% – 14.6%	25.9%

Figure 3

PJm load–Wind gap

2009–2012



The Perverse Effects of Wind Subsidies

Our analysis demonstrates that subsidized wind is least available when the value of electricity is greatest. Thus, not only is wind an intermittent, unpredictable resource, but it can't be counted on to be available when most needed (and valuable). One would be hard-pressed to design a more perverse subsidy that, through a PTC and state RPS mandates, subsidizes a generating resource that produces electricity when it is least needed.

The adverse economic impacts of subsidized wind generation extend beyond subsidizing a low-value generation source. Wind generation suppresses market prices in the short run by providing supply when the wind is blowing. Some wind proponents believe that suppressing market prices benefits consumers by transferring "ill-gotten gains" from producers. Viewed in this light, subsidized wind imposes a type of "windfall profits" tax on existing generators. However, contrary to price suppression proponents, the reality is that such policies fail to address market dynamics and the behavior of suppliers in response to lower prices.

A simple example of the dynamic response to subsidized wind is shown in Figure 4. This figure reproduces the load duration curve of Figure 1 and the four types of generating resources. Now, assume subsidized wind generation W is added to the mix (the quadrilateral at bottom). Based on the previous analysis, the least amount of wind will be available during highest demand hours. Thus, in Figure 4, the amount of wind generation is assumed to increase as we move further to the right on the load duration curve.

As more wind is generated, suppressing market prices, existing competitive generators will realize lower economic returns. Consequently, marginal baseload and intermediate generators will begin exiting the market. In the figure, B' of baseload capacity, I_1' of Type 1 intermediate capacity, and I_2' of Type 2 intermediate capacity are assumed to exit prematurely in response to the initially suppressed market prices over the short run. However, because so little wind generation is produced during peak hours, existing peaking generation, P, will then pick up the slack from the other generators' exit. In the highest demand hours, additional, even-higher-cost peaking resources, P', will be brought

FigurE 4

Dynamic Response to subsidized Wind generation

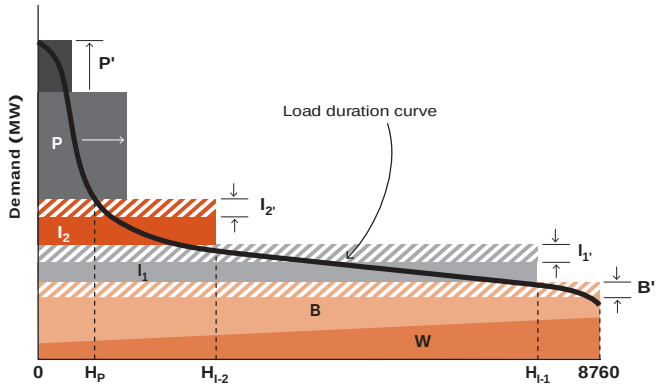
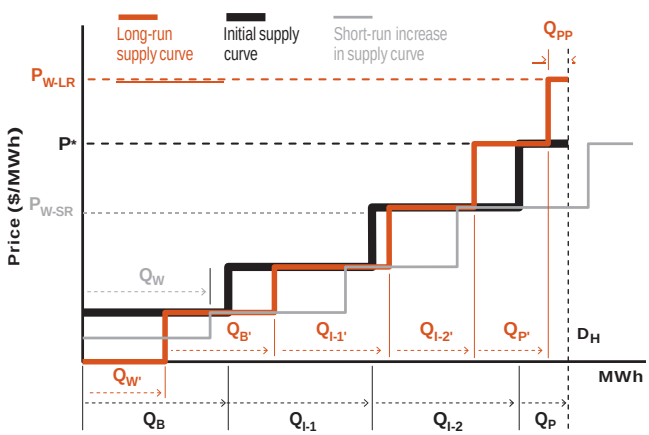


FigurE 5

effect of generator Retirements



online to meet demand. The net result is that in the long run, subsidized wind generation will cause market prices to increase.

Another way to view these impacts is shown in Figure 5. In the figure, the initial market price in a given hour with demand D_H is P^*. The demand is met with the four types of resources B, I_1, I_2, and P, supplying Q_B, $Q_{I\text{-}1}$, $Q_{I\text{-}2}$, and Q_P MWh, respectively. Next, subsidized wind generation, W, is introduced, which produces up to Q_W MWh. This expands the supply curve to the right and reduces the market price from P^* to $P_{W\text{-}SR}$.

However, in response to the lower market prices, existing suppliers prematurely retire capacity, shifting the supply curve back to the left. As a result, in high-demand hours, much less wind will be available. Specifically, assume that only $Q_{W'}$ MWh of wind is produced when demand is D_H. With the premature retirements, resources B, I_1, and I_2 produce less electricity, reducing the quantities to $Q_{B'}$, $Q_{I\text{-}1'}$, $Q_{I\text{-}2'}$, respectively, and creating a new long-run supply curve (red line). The reduced quantities of baseload and intermediate generation require greater production from the previously used peaking generation P. Thus, Q_P is assumed to increase to $Q_{P'}$ MWh. However, because of the reduced output of the wind resource, additional, higher-cost peaking resources, PP, are brought online, which provide the additional Q_{PP} MWh needed to meet demand. Thus, the addition of subsidized wind leads to higher market-clearing prices.

Additional Societal Costs of Wind Power

The societal costs of subsidized wind do not end with the adverse effects on existing suppliers and higher long-run prices. The geographic disparity of wind resources—wind generation is typically constructed in remote rural areas—requires construction of high-voltage transmission lines to deliver wind-generated electricity to load centers. However, wind developers bear only a small fraction of those costs because they are socialized among all transmission system users. Such cost socialization is the result of federal and state policies to promote wind generation.

There is justification for the socialization of some transmission-system costs, because transmission capacity provides for reliable electric service, which is a public good. Thus, to the extent that additional transmission capacity increases overall system reliability, a reasoned economic argument can be made that, because all users of the transmission system benefit from improved reliability, the costs should be shared among all users. In essence, this is a beneficiary-pays approach to cost allocation.

However, subsidized (and unsubsidized) wind generation does not improve reliability. It *reduces* reliability because of the inherent variability of wind output, which requires additional back-up generation and creates "wind integration" costs to "smooth out" the variation in wind output. Despite this adverse reliability effect, the costs of new high-voltage transmission capacity built to deliver wind-generated electricity onto the power system are still socialized among all users, who then incur yet more costs to maintain the reliability of the power system because it is adversely affected by wind-generated electricity. The net effect is to increase the magnitude of the costs that are socialized because subsidies encourage excess wind development.

Are There Offsetting Societal Benefits to Wind Power?

One potential argument for continued subsidization of wind generation, despite the adverse impacts of such subsidies, is that wind development provides offsetting societal benefits. Such public benefits do not include job creation—green or otherwise—as jobs are not an economic benefit per se, but instead represent a form of transfer payment.

For such a "social benefits" argument to be valid, wind subsidies would have to satisfy several tests. First, does subsidizing wind generation provide social benefits and, if so, what are they? Second, does subsidizing wind generation provide these identified social benefits at the lowest possible cost? In other words, can the benefits be obtained through alternative policies that do not require subsidizing wind development?

The standard litany of social benefits provided by wind are (1) reduced emissions of air pollutants; (2) greater energy

"independence," which generally means reduced dependence on crude oil from the Middle East and other countries that are considered "hostile" to the United States; and (3) reduced fossil fuel price volatility.

Although a reduction in emissions of air pollutants represents a social benefit, there is no empirical evidence that subsidized wind development reduces emissions in an efficient manner, for at least four reasons. First, criteria pollutants such as sulfur dioxide and oxides of nitrogen are already regulated under the Clean Air Act. Therefore, the social costs of these pollutants are already internalized. Second, although renewable energy proponents tout the ability to reduce carbon emissions, there is no consensus on the social cost of carbon emissions, if any. Third, the emissions "avoided" by wind generation depend on the marginal generator. Fourth, the variability of wind generation requires additional fossil fuel back-up generation, which results in fossil fuel generation being operated inefficiently. An analogy is operating a car in stop-and-go traffic versus a constant speed on a highway: the efficiency of the former is less than that of the latter. Furthermore, any cataloging of wind generation's putative social benefits must also include its social costs, such as human health impacts arising from exposure to low frequency noise, killing of migratory birds, and reductions in property values because of impaired views.

Energy independence is not a social benefit. Even if it were, there is no evidence that wind generation reduces the U.S. demand for crude oil from "hostile" countries. In 2011, less than 1 percent of all electricity was generated with oil-based fuel. And, given that oil-fired generators are typically used as peaking resources, the analysis above indicates that such generation will become more common as a result of wind subsidies. As for wind generation providing electricity for electric vehicles and thus reducing oil consumption for transportation purposes, any effects from this would be vanishingly small given the current, and likely future, penetration of electric vehicles relative to total vehicle stocks.

Reduced fossil fuel price volatility is also not a social benefit. Moreover, there is no evidence that wind generation reduces fuel price volatility. Claimed reductions in price volatility are based on a simple—and incorrect—assumption that fossil fuel price volatility increases as demand increases. While it is certainly true that if demand for a good is reduced to zero there will be no volatility in its price, there is no evidence that wind development has reduced the volatility of fossil fuel prices. Besides, traditional hedging instruments can reduce price volatility to any level desired by consumers, at a lower cost and without the need for subsidies.

Conclusion

Continued subsidies for wind generation, both in the form of tax credits and mandatory renewable portfolio standards, represent bad economics and bad energy policy, for at least three reasons. First and foremost, wind generation's production pattern is not only volatile and unpredictable, it also has low economic value. Rather than displacing high variable-cost fossil generating resources used to meet peak demand, wind generation's availability peaks when electricity demand is lowest. As a result, wind generation tends to displace low variable cost generation or simply forces baseload generators to pay greater amounts to inject power onto the grid because the units cannot be turned off and on cost-effectively. Thus, consumers and taxpayers are forced to subsidize low-value electricity.

Second, subsidized wind generation, like all subsidies, distorts electricity markets by artificially lowering electricity prices in the short run, but leads to higher prices in the long run. This imposes economic harm on competitive generators and consumers. Subsidies drive out competitors and increase financial uncertainty, thus raising the cost of capital for new investment in generation. In the long run, the impact of subsidies is electricity prices that are higher than what would prevail in a fully competitive market.

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Third, subsidized wind generation results in additional social costs that are borne by consumers. Those costs include billions of dollars that must be spend on additional high-voltage transmission lines, which have their own adverse societal impacts, as well as additional costs that are incurred to integrate variable and intermittent wind generation onto the grid. In other words, wind generation imposes external costs on other market participants.

After 35 years of direct and indirect subsidies, there is no economic rationale for continued subsidization of wind generation. At the federal level, direct subsidies such as the federal PTC should be ended immediately. Similarly, state-level subsidies, whether feed-in tariffs established by state regulators or statutory RPS mandates, exacerbate market distortions and raise electricity prices, again to the detriment of consumers. These state subsidies should also be eliminated.

Ultimately, continued subsidization of wind generation simply rewards a few niche generation companies and their suppliers, at the expense of the many. Given the massive federal debt and anemic U.S. economic recovery, this type of pernicious wealth redistribution cannot be justified. R